

CLAIMS

What is claimed is:

- 1) Multicycle integration focal plane array (MIFPA), linear or area, which is a new type of electronic apparatus, and, unlike the existing FPA composed of a single-cycle integrator, is composed of
 - a) a correlated multicycle integrator that can be incorporated into an integrated circuit for each pixel of the MIFPA;
 - b) signal **10** being modulated either passively by a mechanical or electronic chopper **11** or actively by a pulsed light source **15**;
 - c) background (and/or dark current) **14** being unmodulated;
 - d) the input current **17** comprising the modulated signal and unmodulated background being fed to an integrator;
 - e) so that the signal being accumulated while the background being cancelled;
 - f) so that the signal to noise ratio and dynamic range can be greatly improved.
- 2) The method of using MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, which comprises the following steps:
 - a) a lens or lens system **12** is placed between the scene or object **10** for imaging, spectroscopy, or spectroscopic imaging and the multicycle integration focal plane array (MIFPA) **13**, composed of either one- or two-dimensional of photodetectors **16**, where the image and or spectroscopic signal is collected;
 - b) a passive optical modulator **11**, which can be a mechanic chopper, an electric-optical switch, a polarizer, or other devices, is placed between the scene or object **10** and the FPA **13** to modulate the photon flux from the aforesaid scene or object **10** for imaging, spectrum, or spectroscopic imaging;

c) or an active modulator, such as a pulsed light source 15, is used to generate modulated image and/or spectroscopic signals;

d) when the modulator is on in one phase (ϕ_1 in the figure), the current generated by the detector 17 is the signal photocurrent I_s from object or scene 10, plus the DC background current I_b from the radiation 14 not modulated;

e) when the radiation from the imaging target is blocked by the modulator in another phase ϕ_2 , only the DC I_b is present;

f) by controlling the correlated multicycle integrator synchronically with the modulation control signal, using the same correlated controller 28, the integrator 30 charges the capacitor with the signal and background currents in ϕ_1 , but discharges it with background current only in ϕ_2 ;

g) so that the output of 30 is accumulated signal current I_s only (plus the shot noise that is not avoidable);

h) so that the aforesaid accumulated signal current I_s can be fed to any commercial amplifier and/or display for image, spectrum, or spectral imaging using conventional imaging and/or spectroscopic methods.

3) Lock-in multicycle integration focal plane array (LI-MIFPA), linear or area, which is a special type of multicycle integration focal plane array (MIFPA), linear or area, comprising:

a) all the features of claim 1;

b) with the signal accumulation phase ϕ_1 and background cancellation phase ϕ_2 strictly equal in time.

4) The method of using LI-MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, which comprises the following steps:

a) all the steps in claim 2;

b) with the signal accumulation phase ϕ_1 and background cancellation phase ϕ_2 strictly equal in time.

5) Gated multicycle integration focal plane array (G-FPA), linear or area, which is a special type of multicycle integration focal plane array (MIFPA), linear or area, comprising:

- a) all the features of claim 1;
- b) with ϕ_1 lasting an interval of $\alpha\tau$, ϕ_2 lasting an interval of 0 time, and a new phase ϕ_3 lasting an interval of $(1 - \alpha)\tau$
- c) wherein during phase ϕ_3 the integrator 30 is turned off;
- d) wherein $\alpha \ll 1$, or $(1 - \alpha)\tau \gg \tau$.

6) The method of using G-MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, under the condition that the signal duty cycle α is extremely small while the background current is not extremely large, namely $\alpha \ll 1$, while I_s not $\ll I_b$, as in some types of IR fluorescence spectroscopy using nano-second pulse laser excitation, which comprises:

- a) all the steps in claim 2;
- b) with ϕ_1 lasting an interval of $\alpha\tau$, ϕ_2 lasting an interval of 0 time, and a new phase ϕ_3 lasting an interval of $(1 - \alpha)\tau$
- c) wherein during phase ϕ_3 the integrator 30 is turned off;
- d) wherein $\alpha \ll 1$, or $(1 - \alpha)\tau \gg \tau$.

7) Gated lock-in multicycle integration focal plane array (GLI-MIFPA), linear or area, which is a special type of multicycle integration focal plane array (MIFPA), linear or area, comprising:

- a) all the features of claim 1;
- b) with ϕ_1 lasting an interval of $\alpha\tau$, ϕ_2 lasting an equal interval of $\alpha\tau$, and a new phase ϕ_3 lasting an interval of $(1 - 2\alpha)\tau$
- c) wherein during phase ϕ_3 the integrator 30 is turned off;
- d) wherein $\alpha \ll 1$, or $(1 - 2\alpha)\tau \gg \tau$.

8) The method of using GLI-MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, under the condition that the signal duty cycle α is extremely small and the background current is extremely large, namely $\alpha \ll 1$, and $I_s \ll I_b$, as in some types of IR fluorescence spectroscopy using nano-second pulse laser excitation, which comprises :

- a) all the steps of claim 2;
- b) with ϕ_1 lasting an interval of $\alpha\tau$, ϕ_2 lasting an equal interval of $\alpha\tau$, and a new phase ϕ_3 lasting an interval of $(1 - 2\alpha)\tau$
- c) wherein during phase ϕ_3 the integrator 30 is turned off;
- d) wherein $\alpha \ll 1$, or $(1 - 2\alpha)\tau \gg \tau$.